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AN EQUILIBRIUM FLOW MODEL OF THE NAVY'S ENLISTED PERSONNEL ROTATION PROCESS

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13 ABSTRACT

The periodic rotation of enlisted personnel between sea duty and shore duty assignments is a firmly established Navy policy. The efficiency with which the rotation process is managed, however, can have an effect on both the personnel readiness of operating units and the morale of the individual Navy man. This report describes a computerized model of the rotation process which will provide rotation managers in the Bureau of Naval Personnel with a quantitative basis for decisions, and the capability for the test and evaluation of rotation policy. The model encompasses the basic variables and parameters governing the movements of personnel between the broad categories of sea duty and shore duty. The model is based on an "equilibrium flow" concept (i.e., the movements of personnel should be such that the relative proportions of personnel in the sea and shore composites will remain stable) and incorporates certain techniques of actuarial science to estimate the size of future "rotation eligible" populations. The model has been used to test how changes to tour lengths and billet structures would contribute to more orderly and equitable rotation of personnel. Examples of these and other potential application are given.

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by

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August 1972

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Approach

The primary emphasis throughout this effort was [illegible] of models which would incorporate the major elements [illegible] of the sea/shore rotation process in such a way that [illegible] relationships could be measured, manipulated, and if [illegible]. It was intended that these models would provide [illegible] with a quantitative basis for their decisions and a capability to [illegible] and evaluate policy and procedural options related to the planning and control of personnel movements.

This report describes the "Equilibrium Flow Model" which has served as the conceptual framework underlying these model building efforts. This description is prefaced by a brief overview of the personnel rotation system and followed by an outline for the further development and application of the rotation model concept.

Findings, Conclusions and Recommendations

The Equilibrium Flow Model has been developed for use by managers of Navy enlisted personnel rotation systems. It is applicable at all management levels by suitable aggregation of the data for population being managed. Management levels closest to the functional level of personnel

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[illegible] process. [illegible] specific applications might include: (1) [illegible] policy and data inputs; (2) planning personnel [illegible] existing policy and procedural constraints; (3) [illegible] tribution and assignment actions which are triggered by [illegible] [illegible]; and (4) evaluating the overall operation of the rotation [illegible] in terms of specified management objectives (e.g., equitable rotation opportunity, unit stability, "fair share" distribution, career development).

As components of an improved career enlisted rotation system, these models would enable BUPERS rating managers to plan and control the movement, placement, and utilization of enlisted personnel more efficiently and effectively than is now possible under the present system and procedures. In the broad sense, the use of the components of such a system could be expected to lead to more orderly and equitable personnel movements, more effective utilization of skills, greater personnel stability at the unit level, and the capability for more personal and meaningful considerations for the needs, desires, and expectations of the individual enlisted man and woman.

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AN EQUILIBRIUM FLOW MODEL OF THE NAVY'S ENLISTED ROTATION PROCESS*

I. INTRODUCTION

Problem

The planned periodic rotation of enlisted personnel between sea duty and shore duty assignments is a firmly established policy in the Navy. The magnitude of the task of managing these personnel movements in an orderly and equitable manner is great, however. The numbers of personnel involved, the complex relationships with other personnel transactions, and the necessity to respond quickly to actual or proposed changes in the operational environment, often create rotation management problems difficult to isolate and resolve. The need exists, therefore, for the development of a broad range of new or improved management concepts, policies, and procedures based on a systems view of the rotation process. The effort described in this report is in response to this need.

Background

For some time this Laboratory has been developing computer based tools and techniques for application in the Bureau of Naval Personnel (BUPERS) to help improve the management of the enlisted rotation system. This effort has resulted in a series of computerized models of the rotation process which have been used in BUPERS in various planning or policy testing applications. These models have successfully demonstrated not only the feasibility of computerizing portions of the rotation decision making process, but also the improvement in management that could result from their use.

Approach

The primary emphasis throughout this effort has been on the development of models of the sea/shore rotation process which would incorporate the major elements and characteristics of the process in such a way that their values and relationships could be measured, manipulated, and if possible, predicted. It was intended that these models would provide BUPERS rotation managers with a quantitative basis for their decisions and a capability to test and evaluate policy and procedural options related to the planning and control of personnel movements.

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*A modified version of this report was presented as a paper (2) at the Twenty-Ninth Military Operations Research Symposium, U. S. Air Force Academy, Colorado Springs, Colorado, June 1972.

This emphasis has required that a close relationship be maintained with the cognizant BUPERS managers. In effect, this relationship has enabled a continuous analysis to be made of the rotation system. Over the years the objectives for rotation have been redefined or given different priority, new management problems have resulted, and new policies and procedures have been implemented. It has been possible, however, to incorporate into the computer models being developed, many of these changes to the "real world" rotation system.

The general objective has been to try to ensure that the models would be acceptable representations of the actual system, with potential application in helping to solve relevant rotation management problems. For example, after a series of tests, the SEAVEY Planning Model (3,5) was operationally implemented in BUPERS for use in planning the movement of personnel from sea duty to shore duty. More recently, a modification of the Sea/Shore Rotation Model (4) was used by BUPERS managers to help determine how changes to sea/shore billet structures and tour lengths might increase the opportunity for shore assignments for certain enlisted ratings. Actual use of the models in these ways has not only helped to validate their conceptual framework but also provided some immediate benefits to management.

This report describes the "Equilibrium Flow Model" which has served as the conceptual framework underlying these past model building efforts. This description is prefaced by a brief overview of the personnel rotation system and followed by an outline for the further development and application of the rotation model concept.

II. ENLISTED PERSONNEL ROTATION

The Navy enlisted personnel structure comprises approximately 70 occupational skills referred to as "ratings." Each rating is subdivided into "skill levels" which are reflected in pay grade designations ranging from E-1 at the lowest entry level to E-9 which identifies the highest skill level of Master Chief Petty Officer. Additional occupational skills are identified by a numerical coding system referred to as NECs (Navy Enlisted Classification Codes). Assignment of these codes typically follows specialized training and may serve as a skill identifier subsumed either under the broader rating designation or it might identify an entirely separate skill requirement. The Navy's "billet" structure generally parallels the personnel structure and consists of jobs or "tasks" to be performed on board ship or at shore based activities. These are referred to as billets and serve to identify the skills required in support of a variety of missions. It is within this personnel/billet structure that the rotation of personnel takes place.

Objectives

The rotation of enlisted personnel between sea duty and shore duty assignments is intended to achieve two basic objectives. One is to develop in the career force a broad and expanding background of training and experience through a progression of varied duty assignments. The second is to help compensate the Navy man for the hardships he experiences during long tours of sea duty away from his home and family, by providing him shore assignments offering a more normal way of life. The process of rotation is constrained, however, by the need to maintain a high level of readiness in the Navy's operating units. To this end, the transfer and replacement of personnel must be accomplished with minimum effect on crew efficiency and individual productivity, but at the same time, with maximum consideration feasible given to the needs and desires of the personnel involved. In summary, the efficient rotation of personnel can have a significant effect on the overall personnel management system, on the operational readiness of Naval Units, and on the morale and retention probability of the individual Navy man himself.

Rotation Process

As already defined, personnel rotation refers to the planned reassignment of personnel between sea duty and shore duty. The process through which these movements are made is quite simple in theory. With a few exceptions, each Navy ship, aircraft squadron, and shore station is categorized for rotation purposes as either sea duty or shore duty. Men are assigned to these activities for a tour of duty of prescribed length. Normally, when a man completes a prescribed tour of sea duty, he will be rotated and reassigned to a shore duty activity. Similarly, a man completing a tour of shore duty will receive a sea duty assignment (6).

It should be noted, however, that the rotation process merely "triggers" those personnel movements. The actual reassignment of these personnel to new duty stations is carried out through the distribution and assignment process. The distribution function is intended to ensure that each Navy activity receives its "fair share" of the available personnel. The assignment function, in turn, is intended to match as accurately as possible the requirements of specific "billets" with the qualifications and desires of the particular individuals available for assignment. Both the rotation and assignment functions, however, are constrained by distribution policies and procedures. In the simplest sense, the rotation process determines <u>when</u> personnel are to be moved; the distribution and assignment process determines to which areas or billets they should be reassigned.

Rotation Management Problems

Rotation management is primarily concerned with achieving orderly and equitable rotation of personnel between the sea duty and shore duty composites. Orderly rotation refers to the goal of maintaining more or less equal flows of personnel between sea and shore. Ideally, a man rotating from either sea duty or shore duty would be replaced by a man rotating from the opposite composite at about the same time. In this ideal case, there would be neither an undesirable overlap of assignments with both men occupying one of the billets nor an undesirable gap between assignments with one or both billets remaining vacant for a time. A major problem for rotation management is to determine the combination of sea/shore tour lengths that would result in personnel flows at least approaching the order of this ideal state.

The lengths of sea and shore tours are also factors in achieving the management goal of equitable personnel rotation. In this sense, "equitable" refers to the state where there would be equal sea tours and shore tours for all personnel in all ratings. At present, this is not the case. The inequitability existing among ratings results, for the most part, from the differences in their ratios of sea billets to shore billets. In some ratings where there are many more sea billets than shore billets, personnel are required to spend proportionally longer time at sea than on shore. Where the ratio is more nearly equal, the time spent at sea and on shore is also more equal.* The problem for rotation management, in this regard, is to increase, whenever possible, the opportunity for shore assignment for the appropriate ratings.

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*There are some ratings that have more shore billets than sea billets, and longer shore tours than sea tours. In general, however, over all ratings, there are approximately twice as many sea billets as shore billets.

This is not an easy task however. The number of billets for a rating is, in effect, a statement of where and to what extent the skills of the rating are required. Thus, if a particular skill cannot be utilized in an activity, no billet requirements will be specified. Those ratings representing "shipboard" skills are most often the ones with low shore duty opportunity. How to utilize these ratings ashore in a manner that is both financially practical and productively feasible is the essence of the problem.

Rotation management has traditionally dealt with personnel at the "rating-pay grade-NEC" level because this is the level at which duty assignments are made. This represents the management level necessary to appropriately allocate the personnel resources throughout the Navy. Considering the amount of detail, the inherent complexity, and the magnitude of the management task, this level could be referred to as the "microlevel" of rotation management. Higher level managers and policy makers have little need for the detail required at the microlevel, utilizing instead generalized data representing selected aggregates of personnel. The present personnel/billet structure lends itself readily to several possible intermediate management levels such as aggregates of personnel by total rating, rating groups (i.e., a collection of related occupational specialties), or by pay grade across ratings. The highest practical management level would consider total Navy sea and shore aggregates for purposes of rotation management. This top level could be referred to as the "macrolevel", existing at the opposite extreme from the microlevel.

The "Equilibrium Flow Model" described in the next section has potential application at each of these levels of rotation management.

III. EQUILIBRIUM FLOW MODEL

The "Equilibrium Flow Model" represents the framework underlying the various models of the sea/shore rotation process which have been developed as part of this research effort. This section includes descriptions of (1) the concepts and assumptions upon which the model is based, (2) its computational elements, and (3) some policy testing applications. Although the model is computerized, portions of the following descriptions are presented in geometric terms to help the reader visualize the relationships among the elements along with the dynamics resulting from varying selected parameters.

Concepts and Assumptions

The models of the sea/shore rotation process are based on three major concepts which, in turn, are based on several assumptions about the rotation system, the relationship between certain variables, and the characteristics of the sea/shore populations of personnel. These concepts and assumptions are described below.

1. The Dynamic Equilibrium Concept

It is assumed that, ideally, the rotation system should be in equilibrium in the sense that the relative proportions of personnel in each composite should remain stable. As already noted, one of the major constraints operating in rotation management is the number of billets within the sea/shore composites. In many ratings, however, the total number of personnel available is insufficient to "man" all of these billets. In such cases, "manning levels" are established to indicate the proportions of billets in each composite that will be manned. The rotation of personnel must, therefore, be carried out in a manner that will maintain the composite manning in an equilibrium condition.

There are, however, a number of forces constantly acting to disrupt any achieved equilibrium. Sea/shore billet requirements, personnel inventory levels, personnel management policies, and operational commitments are in a continual state of flux. More accurately then, rotation management could be considered as the process of trying to maintain a "dynamic equilibrium" (7) within a turbulent environment.

2. Personnel Flow Concept

Management actions associated with personnel rotation involve the transfer of personnel upon completion of predetermined tour lengths. When personnel are moved for rotation purposes, a vacancy is created that must also be dealt with. Ideally, as part of the rotation concept, there will be someone waiting for assignment to the billet being vacated upon simultaneously completing his own assigned tour. This creates another vacancy to be filled by yet another move, so that there is in effect a chain reaction of reassignments and vacancies throughout the system.

The mechanics of rotation, then, may be viewed as a set of billet vacancies occuring regularly over time with a concurrent movement of individuals between the two broad composites of sea and shore populations.

The "Personnel Flow Concept" refers to this movement of personnel and the interaction between numbers of personnel and tour lengths (11) generate somewhat predictable flow rates. In effect, it is assumed that the number of personnel moving from a composite each month is a function of the number of people in the composite and the prescribed tour length in months. This relationship can be expressed as:

$$F = \frac{N}{T} \tag{1}$$

where: N = number of rotatable personnel

T = tour length in months

F = personnel flow rate per month

A geometric representation of these basic rotation elements in determining a "shore vacancy rate" is shown in Figure 1.

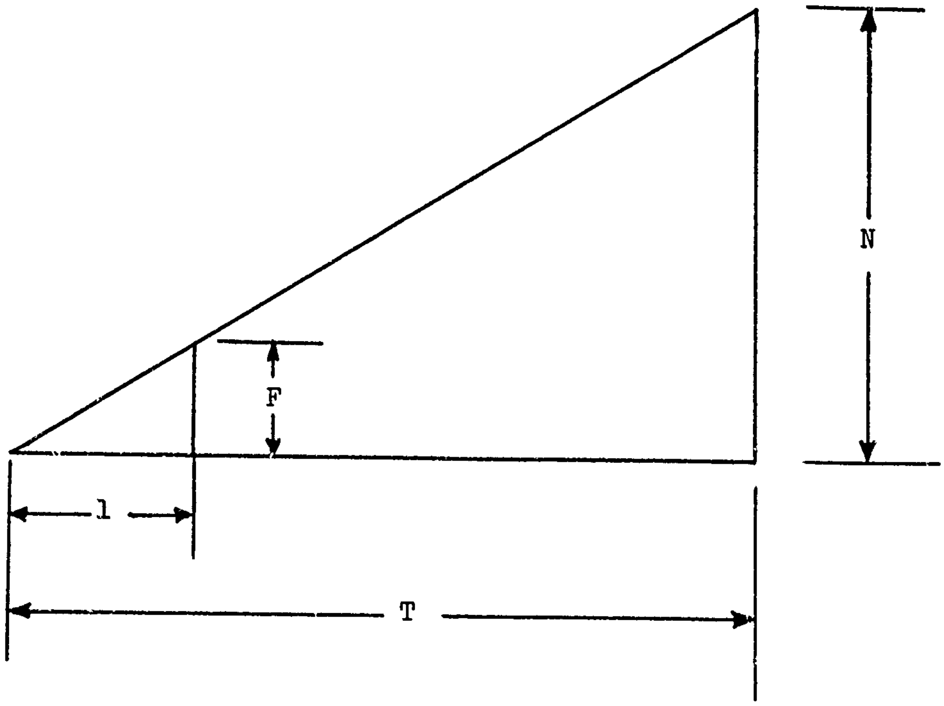


Figure 1. Personnel Flow Rate (F) shown as a Function of Numbers of Rotatable Personnel (N) and Length of Shore Tour in Months (T).

In Figure 1 the personnel flow rate (F) is the portion of the total number of personnel (N) that has moved during the basic time unit of one month. As additional time passes, the supply of vacated billets accumulates until the complete tour length has elapsed at which point the entire original population will be completely displaced by a new population. With billet supply being set equal to the demand for vacated billets among the sea population, the personnel flow rates will be the same for both composites. This relationship between the "shore vacancy rate" and the "sea replacement rate" is shown in Figure 2, where the slope of the hypotenuse represents the identical flow rate between the two populations.

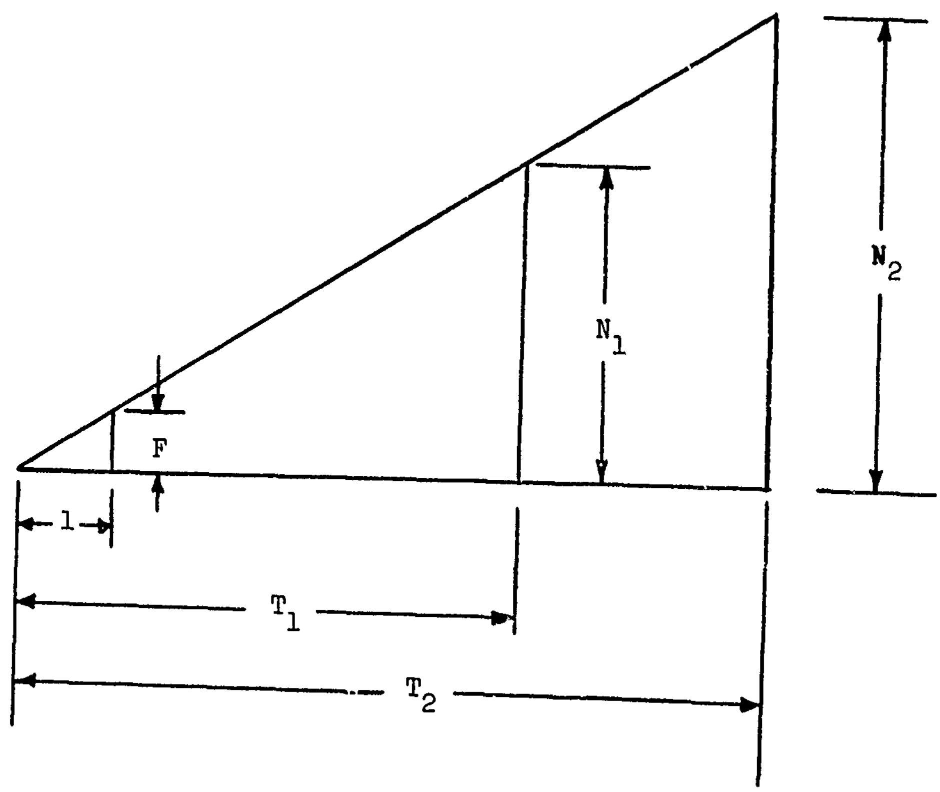


Figure 2. Personnel Flow Rates (F) as a Function of the Number of Rotatables in Each Composite (N_1, N_2) and the Proportional Tour Lengths of Each Composite (T_1, T_2).

The relationship shown in Figure 2 can also be expressed as:

$$(2) \qquad \frac{N_1}{T_1} = F_1 = F_2 = \frac{N_2}{T_2}$$

where: N_1, N_2 = Number of rotatable personnel in the shore and sea composites, respectively

T_1, T_2 = Tour length in months for shore and sea

F_1 = Shore vacancy rate per month

F_2 = Sea replacement rate per month

From the relationships shown in Figures 1 and 2, and expressed in equations (1) and (2), the values of one or more variables can be changed to determine the resulting effect on the others. For example, one could determine the appropriate sea tour for a given sea/shore billet ratio and prescribed shore tour, or how many additional billets would be needed for equal sea/shore tours holding the size of the sea population constant.

In actuality, of course, the rotation system is seldom exactly in equilibrium and the flows of personnel between sea and shore are seldom exactly equal. The Dynamic Equilibrium Concept and the Personnel Flow Concepts are important, however, because they enable the variables affecting the rotation process to be mathematically related. By so doing, they can represent the ideal against which to measure the present rotation process and to test existing or proposed rotation policies.

3. Rotatable Population Concept

An analysis of the rotation process has shown that not all personnel serving at sea or on shore at a particular time will necessarily be eligible for rotation at a future time. Some personnel will be in special programs or in billets which are managed outside of normal rotation procedures. Before completing a prescribed tour of duty, some personnel may leave the service while others may be promoted to another pay grade or transferred to another rating where a different tour length policy might apply. Some others may complete a tour but be ineligible to rotate because of insufficient obligated service or because of operational commitments. Therefore, in order to effectively plan the movement of personnel, some assumptions must be made about the nature and size of the "rotatable population" which can be expected to be eligible for rotation at some future time.

Predicting the size of future populations has historically been viewed as a problem of predicting future numbers from analysis and interpretation of Navy "reenlistment rates." Close examination of the reenlistment rate concept, however, indicates that it has certain limitations that reduce its effectiveness for purposes of rotation management. A more suitable rate for the purpose mentioned may be developed by analysis of the number of personnel who remain in service as measured by the proportions of personnel at each year of service that continue into the following year. These rates are referred to as "continuance" rates and are developed independently of considerations relating to enlistment contracts (9). One major advantage of a continuance rate over a reenlistment rate is that it maintains a specific relationship to the time dimension that may range from one day to the maximum 30 year service career.

There exists a close mathematical relationship between continuance rates and length-of-service distributions for any given population. Such distributions do not require any assumptions of linearity with respect to rate of change or "normality" of frequency distributions in their application. In addition, the continuing product of continuance rates will generate an equivalent "life survivor curve" for the given population, a profile more suited to rotation management models. The development of a similar curve is illustrated in Figure 3, where an actual population frequency distribution is converted to a "survivor curve" by subtracting from the total population beginning at $TIME_0$ the frequencies for each successive point in time. The curve thus generated is cumulative in the sense that each of the values on the curve represents numbers of personnel at or beyond the corresponding points in time.

The general applicability of an actuarial theory concept to rotation management procedures rests on an analogy drawn among those elements of birth, life, and death in actuarial science (1) and the organizational equivalents of entry into active service, active service, and release from active service. The organizational equivalent of "life expectancy" is referred to as "length-of-service expectancy" or "time-in-grade expectancy" depending upon the nature of the aggregate population under consideration. Development of the concept in the following paragraphs translate other actuarial elements into equivalent organizational elements.

A simple survivor model may be developed by observing a relatively large number of personnel who have entered the organization and noting the effects occurring over time as the number is diminished by those leaving the population (8, 10). This model of a single population may be extended in concept by observing a succession of groups entering the

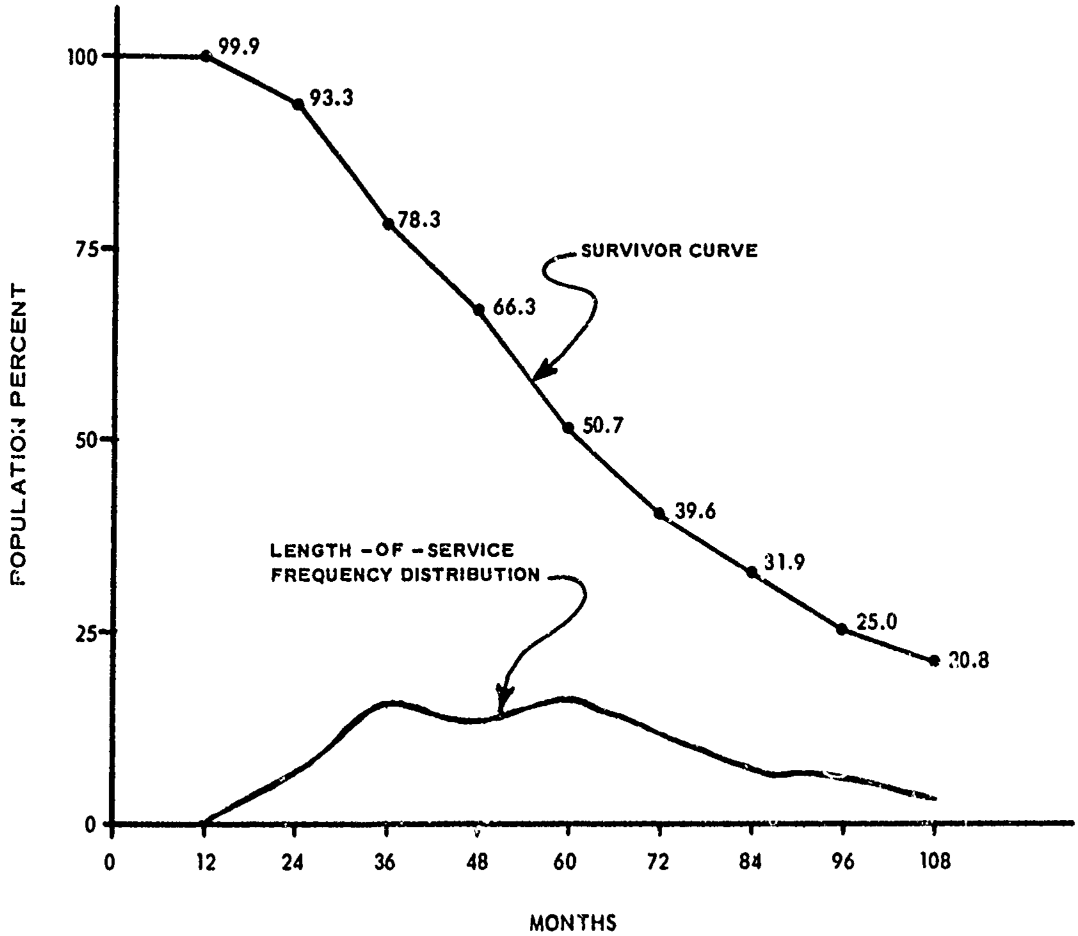


Figure 3. Cumulative Population Survivor Curve as Developed from a Length-of-Service Frequency Distribution.

organization at evenly spaced time intervals such as years. As time passes, each year group will move from one "length-of-service" time interval to the next. When the maximum length-of-service time span has elapsed, an equivalent to the life span of a population, the first group will have been diminished to zero. Once this point has been passed, there will remain within the total population, a stabilized distribution of personnel by length-of-service categories for, as some personnel are lost from the population they are replaced by others moving in from the next shorter length-of-service group. The values determined for each selected point in time may be plotted graphically to form a "survivor curve" for the population. Figure 4, illustrates a survivor curve envelope for actual data representing total Navy population for the years 1966 through 1971 showing the relative stability of the population in terms of a cumulative length-of-service frequency distribution. Only the highest and lowest values for this period have been plotted.

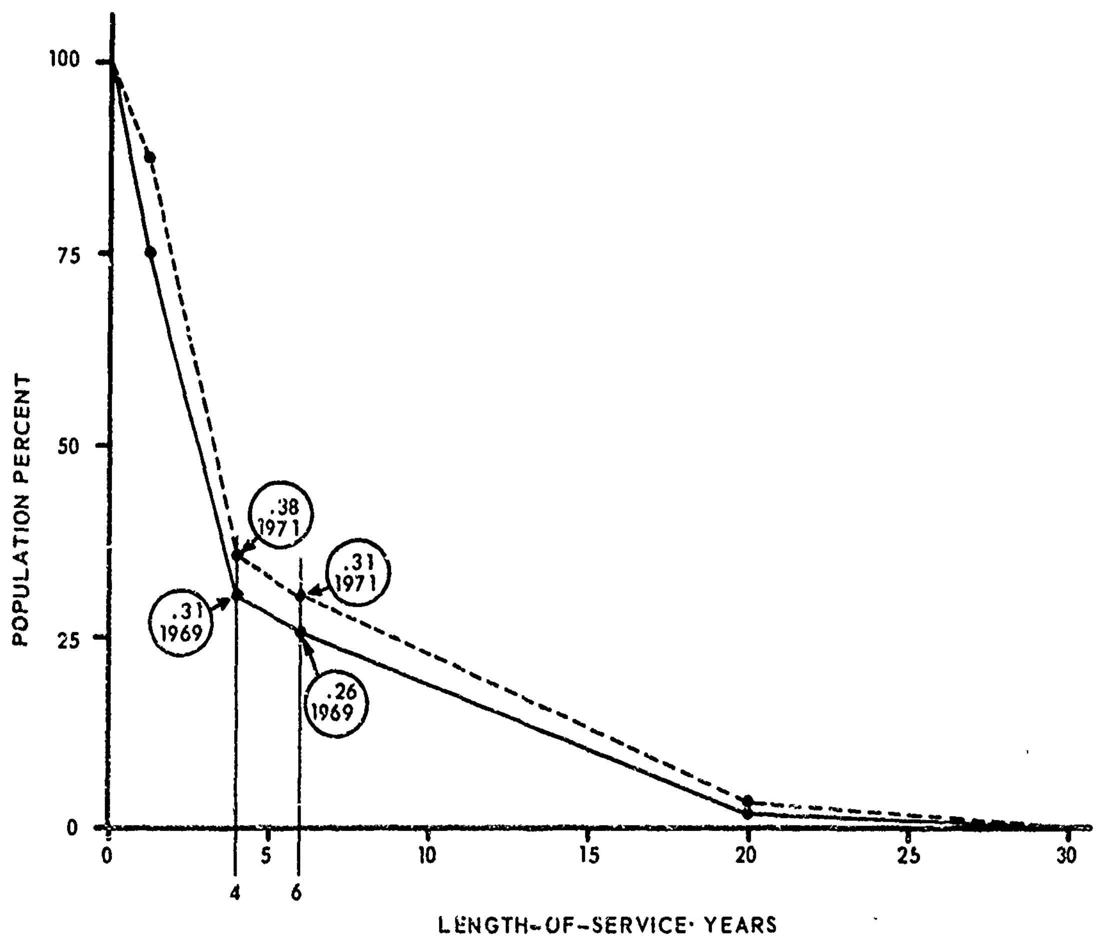


Figure 4. Survivor Curve Envelope for Total Navy Population for Years 1966 through 1971.

This model of a stationary population approximates very closely the structure of an existing population where losses at each point in time are used to generate requirements for replacements. This is generally true in the Navy's determination of promotion requirements. This concept already exists in Navy planning where the stationary population is referred to as the "force structure." That application is to total Navy population where the numbers are large, but the concept has equal application to subpopulations represented by various aggregates subject to a variety of management actions such as rotation. The data can be expected to exhibit somewhat less stability as population size decreases, but longitudinal data samples can aid the manager in determining possible trends or other fluctuations that must be anticipated. Advance knowledge of pending policies relating to early discharges, reenlistments, delayed or accelerated promotions, etc., can be of considerable aid to the manager in anticipating shifts in force structure that will affect the shape of the "survivor" curve. Similarly, improved personnel retention will produce an age shift in the population that has important consequences for the rotation manager.

Computational Elements

The preceding sections have identified and described the essential elements of rotation management. These are: (1) the number of "rotation identified" sea and shore billets, (2) the time dimension represented by tour lengths, (3) the personnel flow rate, (4) the obligated service required for rotation eligibility, and (5) the "survivor curve" for the population being managed. These elements can now be combined in computational relationships somewhat analagous to an economic model of supply and demand. The description of the computational elements of the basic rotation model will be followed by a description of a version of the model which permits additional management inputs.

Since rotation occurs between the two gross composites of sea and shore, the model structure will be more readily understandable by following the traditional practice of establishing certain fixed parameters for one composite and absorbing necessary adjustments in the second composite. The more stable element in rotation has long been the shore assignment, usually accompanied by assurances of a prescribed minimum tour. This practice will be continued for purposes of model description. Also, for descriptive convenience, billets will be assumed to be manned at the 100 percent level so that numbers of billets and personnel may be used interchangeably.

1. The Basic Rotation Model

The personnel flow rate from sea to shore has been established as identical to the shore vacancy rate resulting from tour completions. Ideally, sea replacements will also be at their tour completions when rotated. The rate of personnel flow may be regulated by the rotation manager through adjustments to the tour lengths. Shore tours are prescribed by policy and serve to maintain a fairly high degree of stability within the shore composite, but sea tours must be determined in relation to the shore vacancy rate, the ratio of sea to shore billets, manning level policies, and size of the "rotatable" sea population.

Figure 5 is a geometric representation of the model where the horizontal time scale is graduated in months to serve as the units of time common to both sea and shore composites. Supply is equivalent to the number of shore billets being vacated in the base composite due to expiring tour lengths, and demand is represented by the number of personnel at sea that are seeking shore billets upon completion of sea tours. In a left to right time orientation, the rising shore vacancy slope and the descending survivor curve commence at time "zero months" and intersect at a point determined by the combined rate of convergence. The separate rates are not necessarily identical, typically they will be different, the demand curve exhibiting relatively slow rates of decline for senior career personnel and rapid rates of decline for lower skill level personnel. A perpendicular dropped from the intersection of the two converging curves will locate an "equilibrium point" representing the length of time that must elapse before the supply of vacated shore billets will equal the demand for shore billets among the sea population. The equal supply and demand numbers may be derived from the vertical scale at a point horizontally to the left of the curve intersection. Since both slopes are cumulative, the measures reflect the number of personnel in each composite that will <u>equal or exceed</u> the tour lengths in terms of length-of-service. They thus comprise the two rotatable populations subject to rotation management.

The foregoing illustration assumed a zero service obligation for rotation eligibility which is only applicable to career personnel with ten or more years of active service. For personnel with less than ten years of service a minimum of 14 months obligation is typically required to insure at least 12 months on an assigned duty station. Those rates with relatively high retention characteristics might be required to obligate themselves for an entire shore tour in order to be eligible for rotation. This obligated service requirement provides the manager with an extra device to manage his population to better meet rotation requirements. The applicable generalization relating to obligated service is that the greater the obligated service requirement that is imposed, the fewer personnel will be available for rotation.

Whatever obligated service factor is selected by a manager, the rotation model can be appropriately adjusted to estimate the resulting equilibrium point. With reference to Figure 5, one can intuitively sense the effect of lengthened service requirements by noting the rate at which the population continues to diminish as time is extended beyond the limits of the sea tour. If eligibility criteria are modified to require longer service, fewer personnel will be available for rotation with

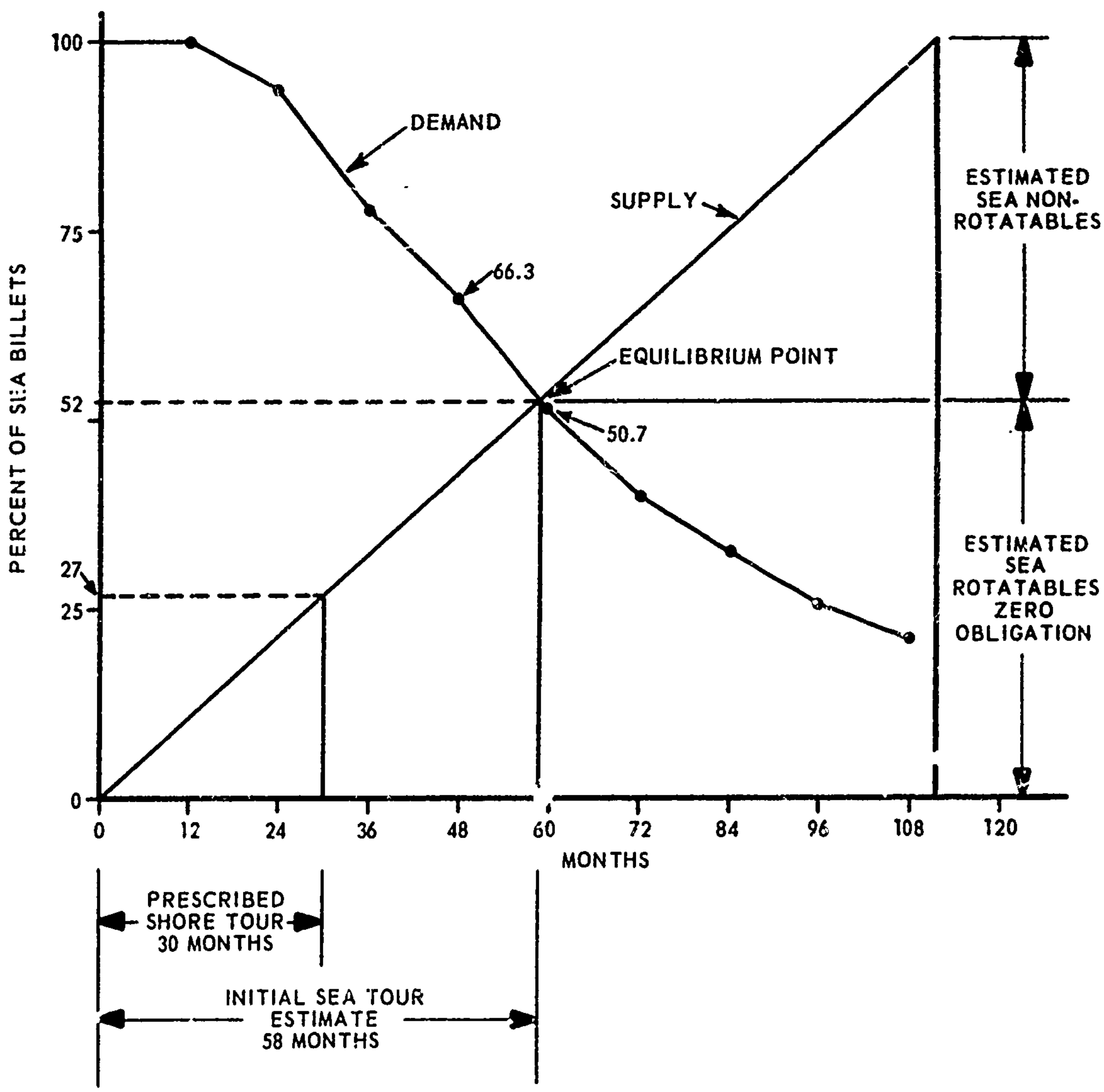


Figure 5. Billet Supply and Demand Rates as Determinants of the Equilibrium Tour Length as Applied to Personnel Rotation.

resultant shorter tours. Conversely, if service obligations are shortened, greater numbers of personnel will be available with resultant longer tours.

For the purpose of illustration, assume that the obligated service requirement is set to the length of the shore tour of 30 months. By viewing the completion of a sea tour followed by a shore tour as a rotation cycle, it becomes convenient to consider rotation as a sequence of tours with alternate periods divided between the two composites. By following the survivor curve beyond the initial 58 month sea tour for an additional 30 months, the population can be observed to decrease from 52 percent of the start population completing the sea tour to 30 percent completing a rotation cycle of 88 months. This procedure, however, fails to establish the equilibrium point for rotation. An adjustment to the location of the survivor curve is necessary in order to incorporate the effects of an extended service obligation. In order to get the survivor curve to appropriately intersect the shore vacancy slope it is necessary to "retard" the survivor curve an amount equal to the **obligation** imposed. This is illustrated in Figure 6 where a set of points on each side of the shore vacancy slope are transferred "backwards in time" to reflect the effects upon the population of a 30 month extension of time. The new equilibrium point is now seen to occur at 43 months, reducing the rotation cycle from 88 months to 73 months, some 14 months shorter than before the obligation was applied.

Since the equilibrium point may occur anywhere along the two curves, the entire survivor curve is "retarded" in the model by moving the 100 percent point in a negative direction away from the zero point of the sea tour so that a time measure equal to the entire rotation cycle is bridged by the survivor curve. The equilibrium point will now occur at a point above the terminal point of the sea tour as shown in Figure 7.

A schematic-conceptual difficulty occurs here in representing this effect geometrically. Personnel serving in the rotation cycle usually start out in the sea tour followed by a shore tour. With time being represented directionally from left to right, the obligation might appear to precede the sea tour. Interpretation requires that the manager recognize that the sea tour occurs first in this instance and the negative months shown for obligated service indicate the time that would remain for an individual upon reaching the rotation point at the end of his sea tour if he were to have rotation eligibility. Once this arrangement is accepted, it becomes a simple matter to input whatever obligated service requirement is desired to determine the appropriate rotation equilibrium point.

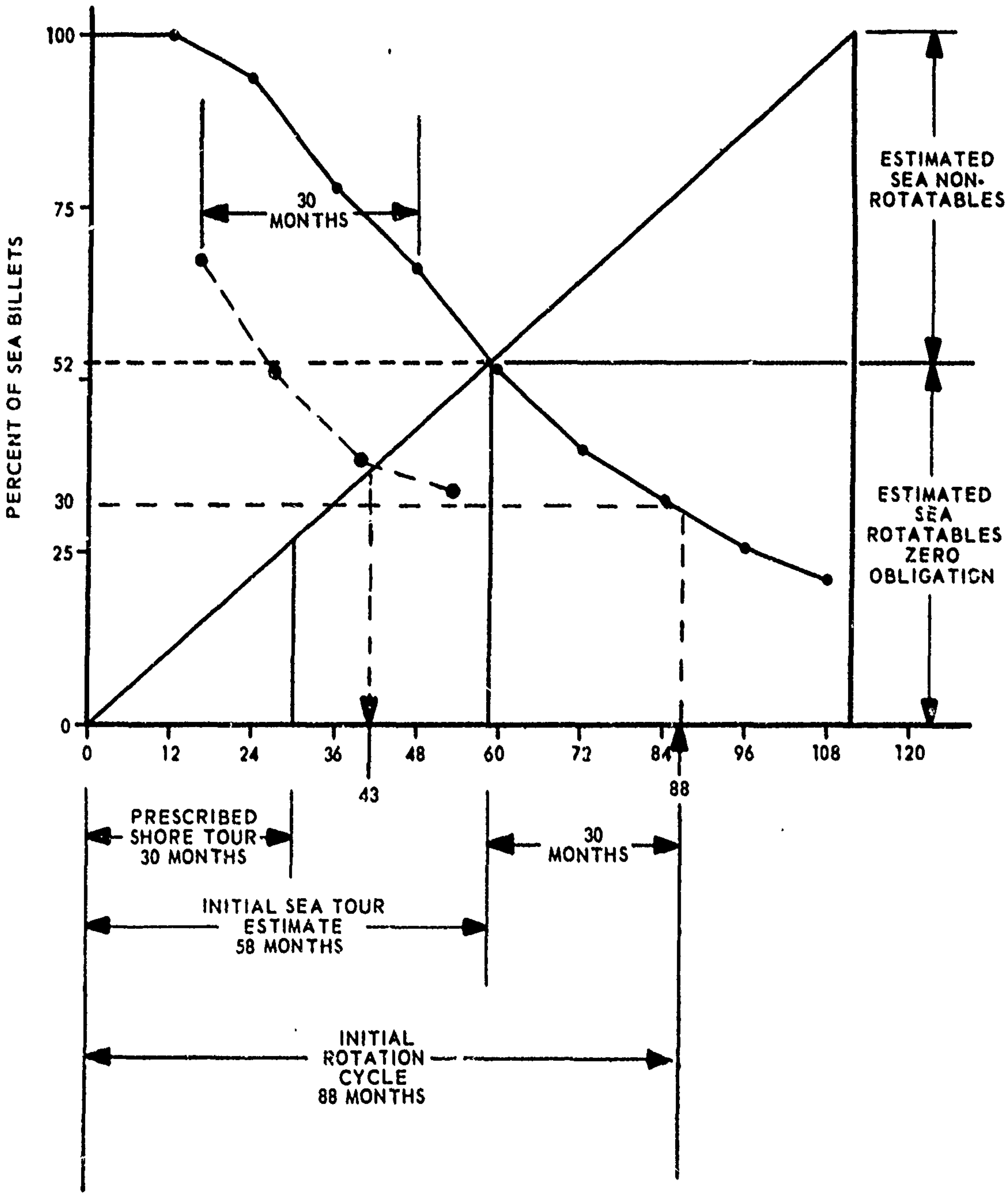


Figure 6. The Personnel Rotation Model Adjusted to Reflect Effects of Applying an Obligated Service Requirement to Rotation Eligibility.

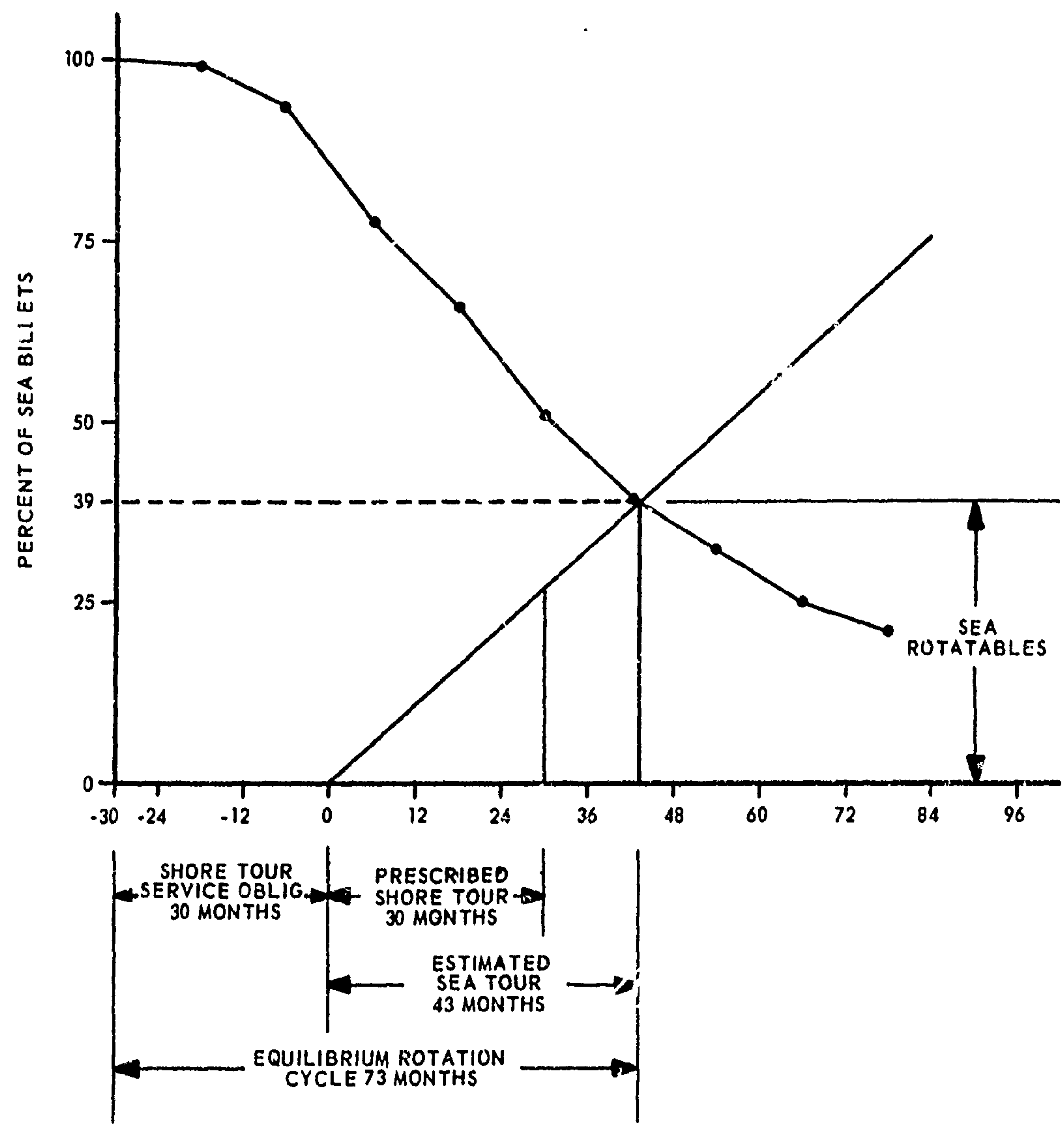


Figure 7. Personnel Rotation Model Incorporating Provision for Obligated Service as a Rotation Management Variable.

2. The Biased Rotation Management Model

Rotation management has been presented as a problem of identifying the quantifying relevant rotation variables and bringing them together in a model that simulates the dynamics of personnel rotation movements over time. Two duty composites are postulated and billet supply and demand rates are derived so as to intersect at a point that represents the equilibrium condition for the variables specified. The actual ongoing condition is extremely dynamic and the model output may or may not fit the realities of the situation for very long periods of time.

To aid the manager in dealing with the uncertainties he will encounter, a deliberate bias may be introduced into the model so as to influence the direction that certain characteristics of the managed population might take. Careful monitoring of the effects of decisions based on this model will serve to inform the manager whether or not the situation is developing as intended.

Figure 8 illustrates the manner in which the rotation model may be structured so as to conform to predetermined and desired characteristics of rotation. One set of supply and demand curves are carefully derived to represent the best estimate of actual conditions. Assume the average shore tour is set at 30 months and a 30 month service obligation applies for rotation eligibility. The equilibrium sea tour for that population according to Figure 8 is 40 months. The manager desires to reduce sea tours for this population and decides to do this by increasing shore vacancy rates by means of shorter shore tours. He selects 24 months as the optimal shore tour and will require 24 months obligated service for rotation eligibility. Now he must study the force structure of the population and seek a survivor curve for expected conditions. He is aware that the population has been experiencing low reenlistment rates and rapid promotion rates, and he foresees little change in the next three to four years. Consequently, he expects the future survivor curve to drop from five percentage points at earlier and later years of the service and up to ten percentage points below the current curve at the four and six year reenlistment points. An adjusted survivor curve is drawn through the series of lower points providing an estimate of the future population depletion rate. The objective of the 24 month shore tour with 24 months obligation will be supported by an equilibrium sea tour of 33 months.

Recognizing this as an estimate and long range goal, the manager may decide to "hedge" a bit and select an intermediate tour for assigning to personnel rotating back to sea. It would be more desirable from a stability point of view to bring about the change in tours gradually. This would give the system a chance to adapt to the implemented changes and permit the manager to evaluate whatever occurs to determine whether or not the system is moving in the direction he intended.

It is important to note that for many rates relatively long time periods must elapse before evaluation is possible. These time periods will more than likely even exceed the rotation manager's own tour so that, in effect, he escapes the consequences of his decisions. This provides an important justification for employing a model for rotation management as a means of providing a management continuity essential to long term control of the rotation process.

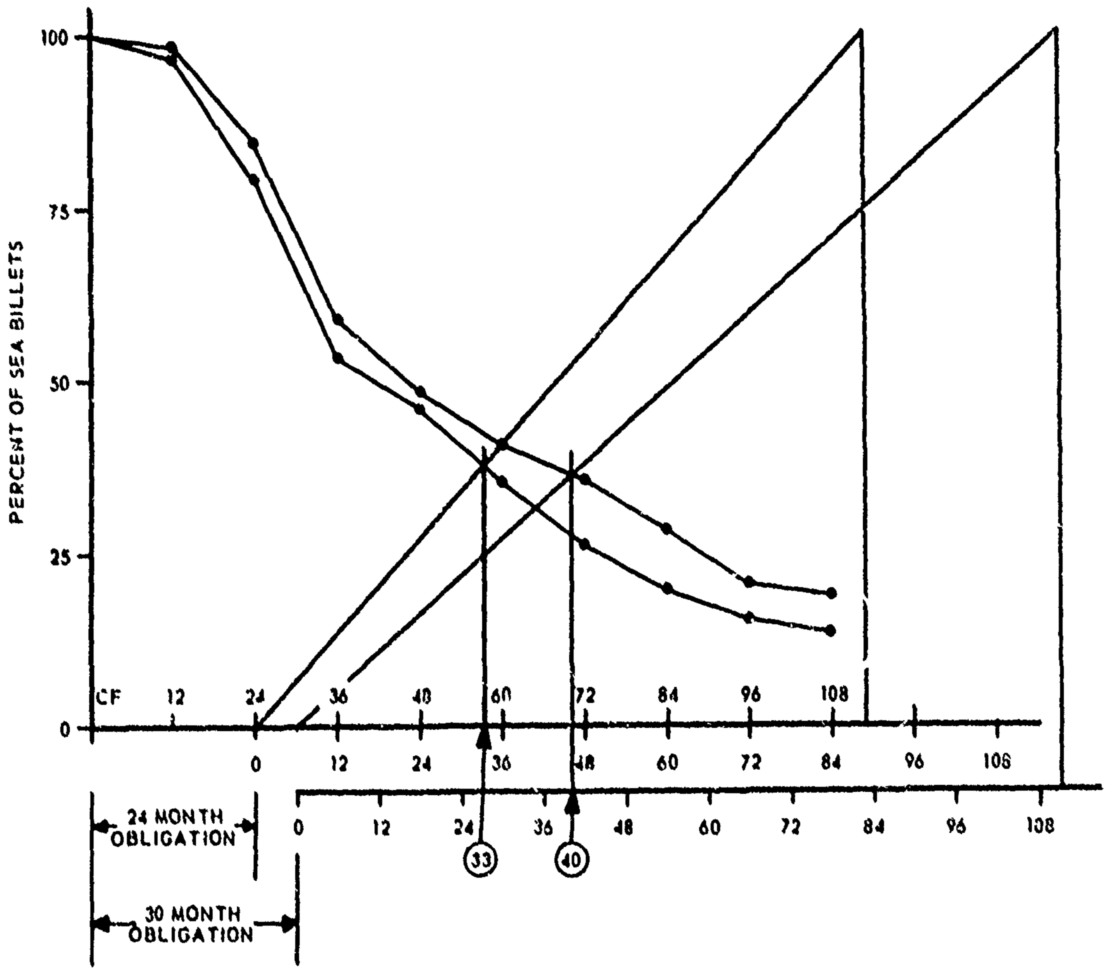


Figure 8. The Biased Rotation Management Model.

Applications

In the preceding section some of the possible applications of the Equilibrium Flow Model were mentioned. This section provides additional illustrative examples of how the model might be applied to problems encountered in rotation management. Each application is presented as a "problem" with the information needed for its solution also given. The solution is illustrated in geometric terms in an accompanying figure. As already noted, the Equilibrium Flow Model is computerized and these applications could be performed by the computer with relative ease. The geometric representations of the problems as given here, are intended to facilitate understanding of the conceptual relationships between the variables as well as the computations that would be performed by the computer.

Five problems have been selected to demonstrate the procedures and versatility of the model. The first problem demonstrates its basic use in determining the equilibrium sea tour for a prescribed shore tour, while the others deal with variations of the basic problem. The problems can be stated as follows:

1. Estimate the length of sea tour necessary to achieve rotation equilibrium for a prescribed shore tour.

2. Estimate the additional number of shore billets needed to support a sea tour after it has been reduced from 72 to 60 months.

3. Estimate the length of reduced shore tour necessary to support a 60 month sea tour after it has been reduced from 72 months.

4. Estimate the length of shore tour necessary to support an equilibrium sea tour that is less than a policy-prescribed minimum 36 months after such sea tour has been increased to the prescribed minimum.

5. Estimate the change to the number of shore billets necessary to provide equal 36 month sea and shore tours in place of actual 30 month shore and 39 months sea tours.

Problem 1.

Estimate the equilibrium sea tour (T) to support a 30 month shore tour (S) and a 30 month length-of-service obligation (R) for rotation eligibility.

Given:

(A) Sea population equal to 100% as a population base.

(B) Profile of a specific "survivor curve" for the rate.

(F) Shore population percentage of the sea population.

(H) Percentage (F) times the actual sea population gives the number of personnel in the shore composite.

(S) Prescribed shore tour equal to 30 months.

(W) The unadjusted sea tour based on sea/shore billet ratios.

(R) Length-of-service obligation for rotation eligibility is set equal to the shore tour (S) of 30 months.

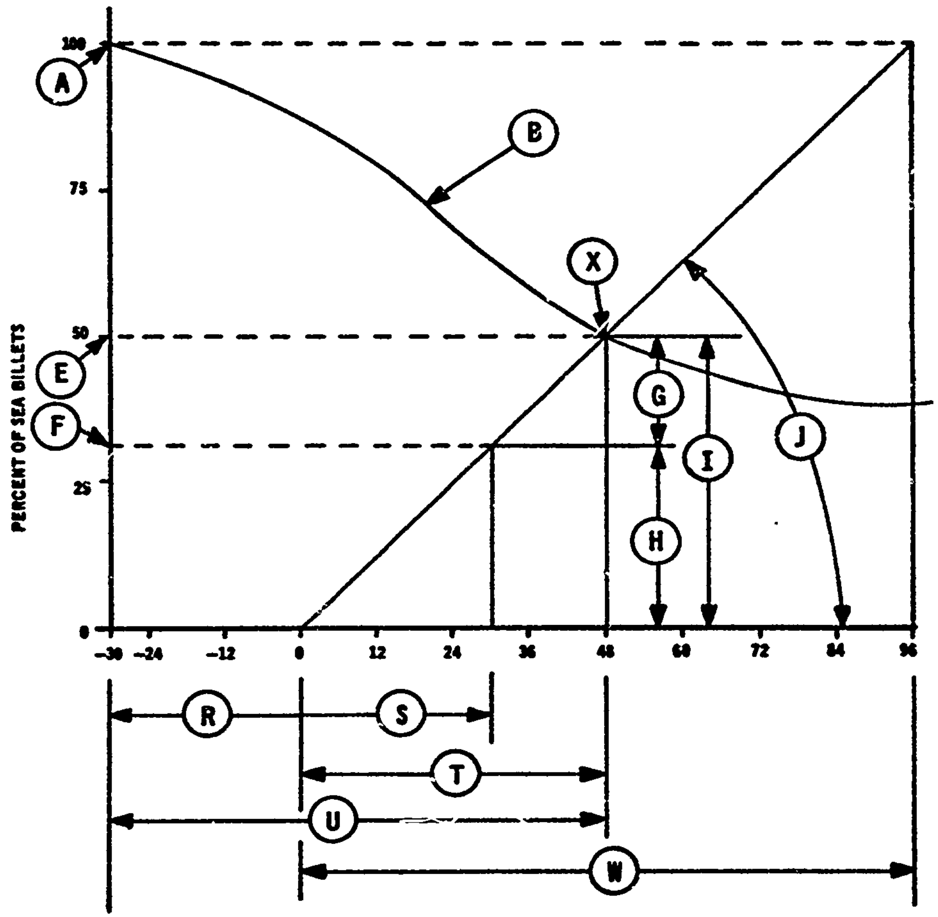
(J) Angle of slope represents the shore vacancy rate determined by the tour length in months and the number of personnel and also the replacement rate of personnel from the sea composite due to tour completions.

Solution:

(X) The equilibrium point resulting during the passage of time (T) after which the accumulated number of shore vacancies due to tour completions will be equal to the number of available personnel from a diminishing sea population (E) also accumulated due to tour completions.

(T) The elapsed time (T) to the equilibrium point (X) represents the appropriate sea tour (T) or the equilibrium tour with respect to the prescribed shore tour (S).

(U) Rotation cycle equals the months summed across one sea tour plus one shore tour.



Problem 2.

Estimate the additional number of shore billets (G) necessary to reduce a 72 month sea tour (V) to 60 months (T).

Given:

(A) Sea billets equal to 100% as a computation base.

(B) Profile of a specific "survivor curve" for the rate.

(F) Shore billet percentage of the sea billets.

(H) Percentage (F) times the sea billets will give the number of shore billets in the initial shore composite.

(S) Prescribed shore tour of 30 months for personnel in shore billets.

(R) Length-of-service obligation for rotation eligibility to shore.

(J) Angle of slope represents shore vacancy rate for a 30 month shore tour (S) and the given number of shore billets (H); angle of slope also represents the identical replacement rate from sea billets for the 72 month sea tour (V) determined by the equilibrium point X_1.

(L) The proportion of sea billets (D) occupied by rotatable personnel for the conditions given.

Solution:

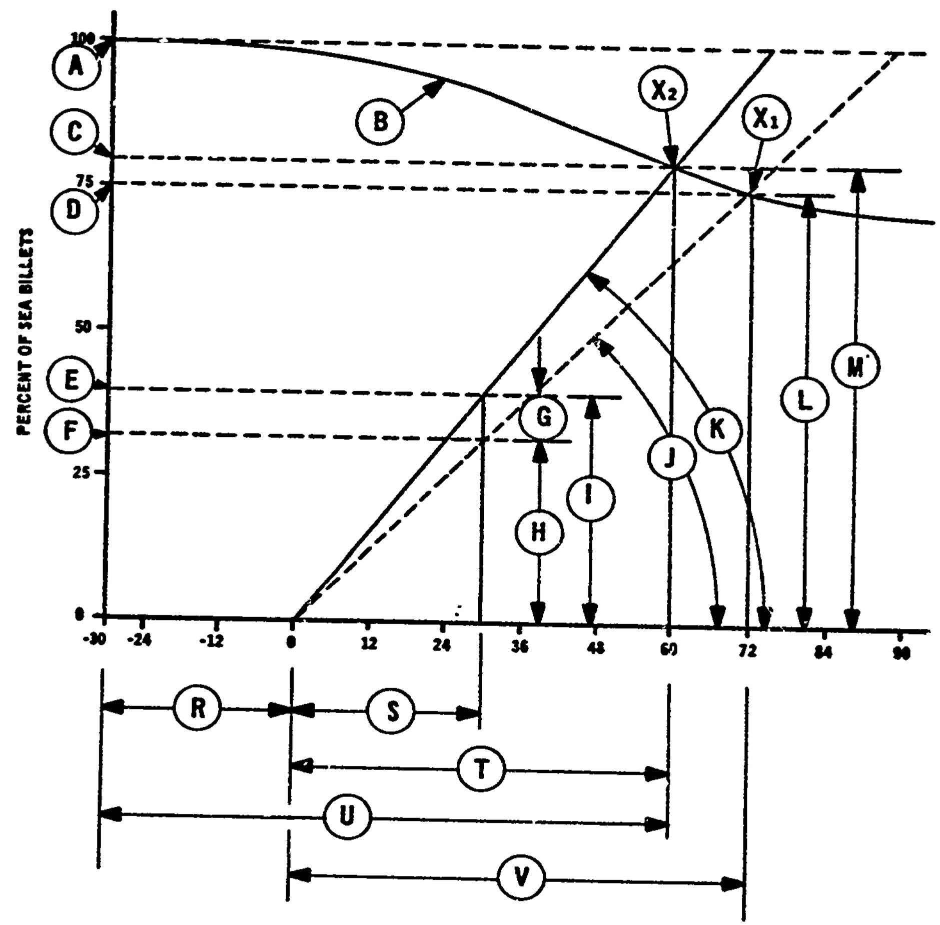
(M) At a point on the time scale located at 60 months for the required tour (T) erect a vertical line to intersect survivor curve (B) at X_2. Interpolated percentage (C) provides an estimate of increased number of rotatable billets resulting from shortened sea tour (V to T).

(K) Draw new angle of slope through equilibrium point (X_2) reflecting increased personnel flow rates resulting from the change.

(I) The increase in the number of rotatable sea billets (L to M) will require additional shore billets (G) to maintain the 30 month shore tour for the reduced sea tour (V to T).

(E) Interpolated percentage of sea billets (A) provides the adjusted number of shore billets (I) that will be required for equilibrium.

(G) The additional number of shore billets necessary may be computed by subtracting the given number of shore billets (H) from the adjusted number (I).



Problem 3.

Estimate the length of the reduced shore tour (P) necessary to support a sea tour of 60 months (T) that has been reduced from 72 months (V).

Given:

(A) Sea billets equal 100% as a computation base.

(B) Profile of a specific "survivor curve" for the rate.

(F) Shore billet percentage of the sea billets.

(H) Percentage (F) times the sea billets will give the number of shore billets in the initial composite.

(S) Prescribed shore tour of 30 months for personnel in shore billets.

(R) Length-of-service obligation for rotation eligibility to shore.

(J) Angle of slope represents shore vacancy rate for a 30 month shore tour (S) and the given number of shore billets (H); angle of slope also represents the identical replacement rate from sea billets for the 72 month sea tour (V) determined by the equilibrium point (X_1).

(L) The proportion of sea billets (D) occupied by rotatable personnel for the conditions given.

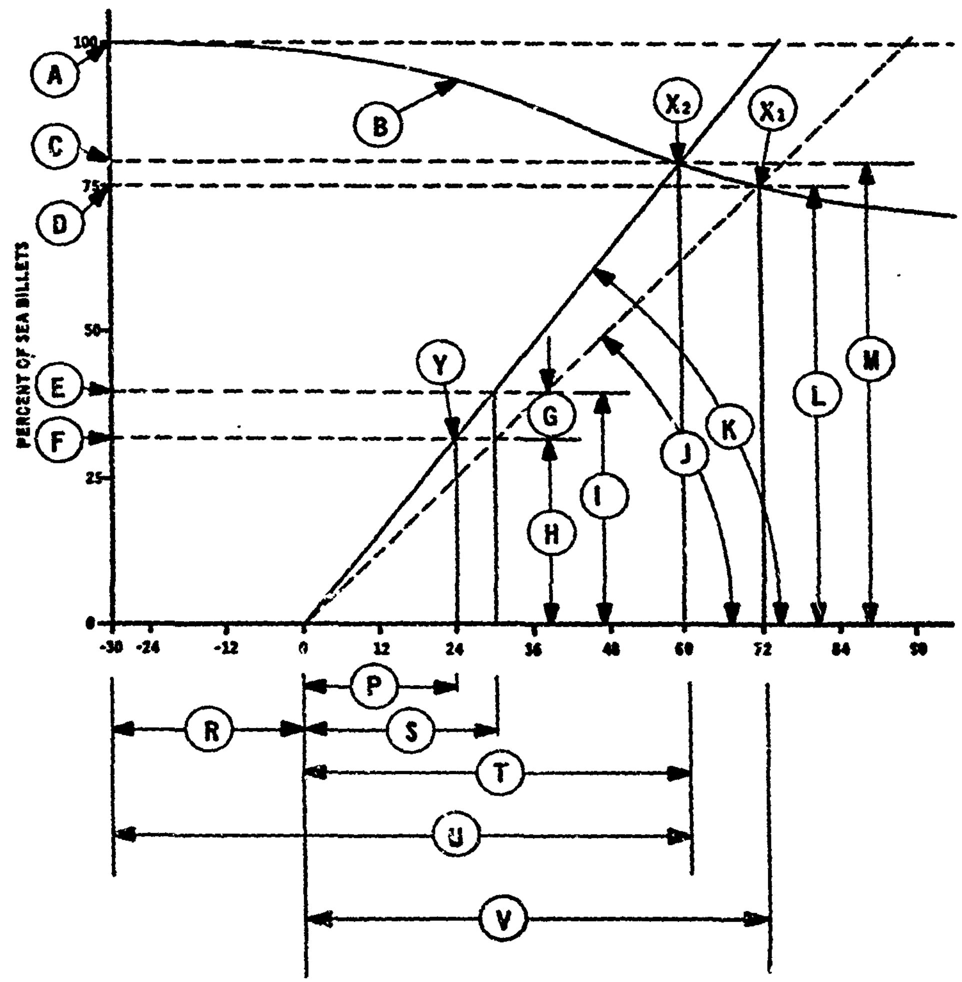
Solution:

(M) At a point on the time scale located at 60 months for the required tour (T) erect a vertical line to intersect survivor curve (B) at (X_2). Interpolated percentage (C) provides an estimate of increased number of rotatable billets resulting from shortened sea tour (V to T).

(K) Draw new angle of slope through equilibrium point (X_2) reflecting increased personnel flow rates resulting from the change.

(F) A horizontal line drawn from the percentage of shore billets which is to be held constant will intersect new slope (K) at point (Y).

(P) A vertical line dropped from intersection point (Y) to the time scale shows the new shore tour (P) will be 24 months.



Problem 4.

Determine the estimated equilibrium shore tour (S_2) where the initial equilibrium sea tour (T_1) is less than the minimum sea tour policy of 36 months, and the initial equilibrium sea tour must be set at the policy prescribed minimum.

Given:

(A) Sea billets equal to 100% as a computation base.

(B) Profile of a specific "survivor curve" for the rate.

(Y_1) Angle of slope (J) for initial condition represents shore vacancy rate for 30 month shore tour (S_1) and the given number of shore billets (H_1) as a proportion (E) of total sea billets.

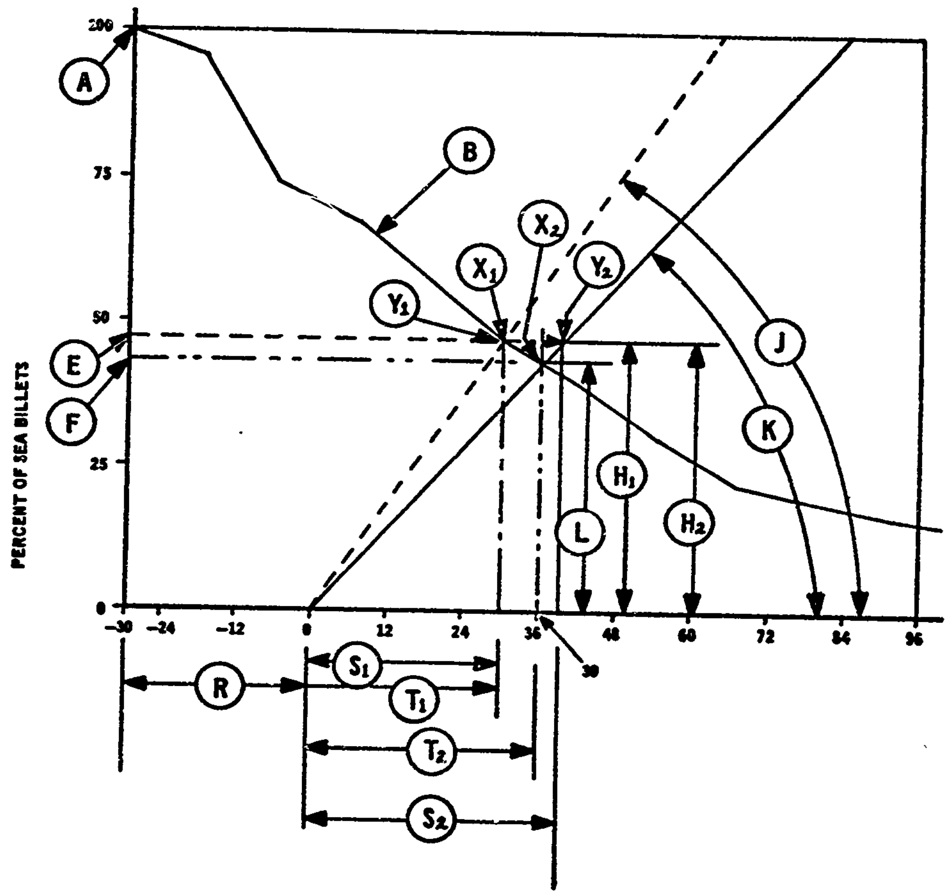
(X_1) Represents the equilibrium point for sea tour (T_1) which in this case happens to be equal to shore tour of 30 months.

Solution:

(K) Angle of new slope intersects survivor curve (B) at (X_2) above the 36 months point and represents a reduced flow of personnel due to lengthened tours in applying the minimum 36 month sea tour policy.

(X_2) Curve intersection represents the 36 month equilibrium sea tour (T_2) as prescribed by policy for a reduced number of rotatables indicated by percentage (F) and height of line (L) for the sea composite.

(S_2) The resultant lengthened shore tour is determined by intersection at point (Y_2) where the same number of shore billets (E) for height of line (H_2) occurs above approximately 39 months on the time scale. Therefore, an initial 30 month sea tour supporting a 30 month shore tour (T_1) converts to a 36 month policy prescribed sea tour (T_2) supported by a 39 month shore tour (S_2).



Problem 5.

Estimate the additional number of shore billets (G) required to provide equal 36 month sea and shore tours (T_2) to replace 30 month shore tours (S) and 39 month equilibrium sea tours (T_1).

Given:

(A) Sea billets equal to 100% as a computation base.

(S) Shore tour prescribed at 30 months for a shore vacancy rate equal to slope (J).

(R_1) Length-of-service obligation for rotation eligibility set at 24 months.

(B_1) Survivor curve set at initial conditions.

(X_1) Equilibrium point indicating a sea tour (T_1) of approximately 39 months for sea rotatables (I_1) as measured by (C_1) as a proportion of sea billets.

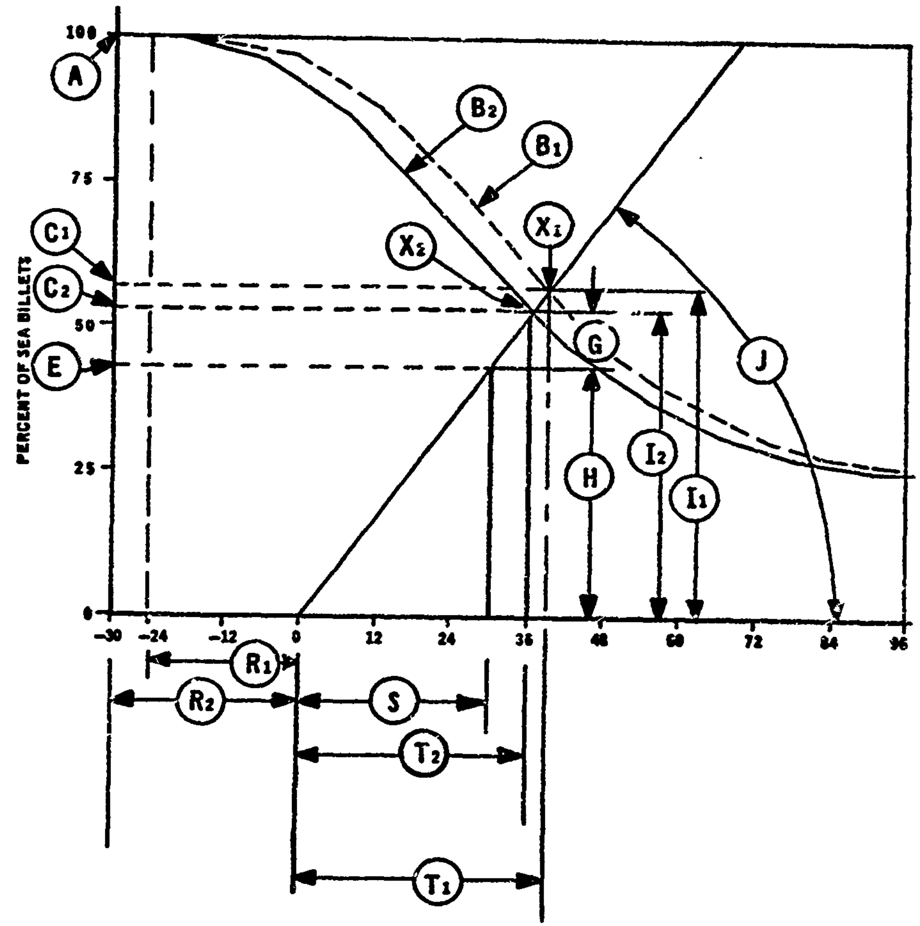
Solution:

(T_2) Represents equal sea and shore tours as specified, obtained by equating shore billets to sea rotatables at (C_2) from a point (X_2) above 36 months on the time scale.

(B_2) The given survivor curve must intersect shore vacancy slope (J) above the 36 month point an time scale. This is accomplished by displacing the curve as measured by initial obligated service (R_1) to (R_2). Shore tour (S) is extended to 36 months (T_2) and sea tour (T_1) is reduced to 36 months (T_2).

(X_2) Represents the new equilibrium point where initial sea rotatables (I_1) are reduced to (I_2) due to movement of the survivor curve (B_1) to (B_2), and initial shore rotatables (H) must be increased to equal sea rotatables (I_2) from (E) percent to (C_2) percent of sea billets.

(G) Represents the required number of shore billets to add to (H) to equal (I_2). ((G) = I_2 - H)



SUMMARY AND CONCLUSIONS

The Equilibrium Flow Model described in this report has been developed for use by managers of Navy enlisted personnel rotation systems. It is applicable at all management levels by suitable aggregation of the data for population being managed. Management levels closest to the functional level of personnel assignment can utilize the model to derive equilibrium tour lengths for prescribed conditions existing for the population they control. They may also use the model to test the probable results of proposed policies such as changes to tour lengths and obligated service requirements. It may be used to resolve rotation problems such as estimating the changes required to the billet structure to improve rotation for selected communities. The model may also serve as a heuristic learning device for training new rotation managers and it may be used to buttress communications efforts to higher levels regarding rotation problem areas.

Higher levels of management concerned primarily with very broad policy determinations may utilize the model to pretest a variety of policies aimed at improving the rotation system over a longer time frame than rotation managers usually consider. Since rotation management usually operates in an open system environment, top managers must evaluate the effects of outside influences such as are reflected in the service cut-backs on manpower, conversion to an All Volunteer Force, effects of a zero draft, large scale ship decommissionings and base closures, and marked changes in retention that may be expected to result from various proposed and implemented policies.

The Equilibrium Flow Model could also be useful as a basis for the development of a family of computer models of the career enlisted personnel rotation system. These models could be used to support the decision-making functions involved in the management of the rotation process. Some specific applications might include (1) testing rotation policy and data inputs; (2) planning personnel movements within existing policy and procedural constraints; (3) monitoring those distribution and assignment actions which are triggered by rotation movements; and (4) evaluating the overall operation of the rotation system in terms of specified management objectives (e.g., equitable rotation opportunity, unit stability, "fair share" distribution, career development).

As components of an improved career enlisted rotation system, these models would enable BUPERS rating managers to plan and control the movement, placement, and utilization of enlisted personnel more efficiently and effectively than is now possible under the present system and procedures. In the broad sense, the use of the components of such a system could be expected to lead to more orderly and equitable personnel movements, more effective utilization of skills, greater personnel stability at the unit level, and the capability for more personal and meaningful considerations for the needs, desires, and expectations of the individual enlisted man and woman.

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